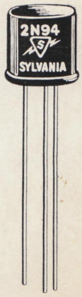

how to make a

transistorized

portable radio . . .

and 20 other practical applications for R-F transistors

SYLVANIA ELECTRIC PRODUCTS INC.

How to Make a Transistorized Portable Radio . . . and 20 Other Practical Applications for R-F Transistors

SYLVANIA ELECTRIC PRODUCTS INC.
1740 BROADWAY • NEW YORK 19, N. Y.

FIRST PRINTING

PREFACE

The development and availability of high-frequency transistors makes possible for the first time the construction and operation of reliable r-f equipment by transistor experimenters. Heretofore, only occasional lower r-f operation was obtained with selected audio transistors.

The r-f transistor was placed on the market after publication of Sylvania's booklet "*28 Uses for Junction Transistors*," which dealt mainly with d-c and low-frequency applications. The need now has arisen for another booklet featuring r-f circuits.

This booklet, devoted entirely to high-frequency transistor circuits, is, like its predecessor, addressed primarily to experimenters and electronic hobbyists but we hope that other workers as well will find useful material on its pages.

No license is to be implied with respect to any inventions described herein, and no responsibility is assumed for the application or interpretation of the information contained herein, or for any infringement of patent or other rights of third parties that may result from the use of that information.

Sylvania Electric Products Inc.

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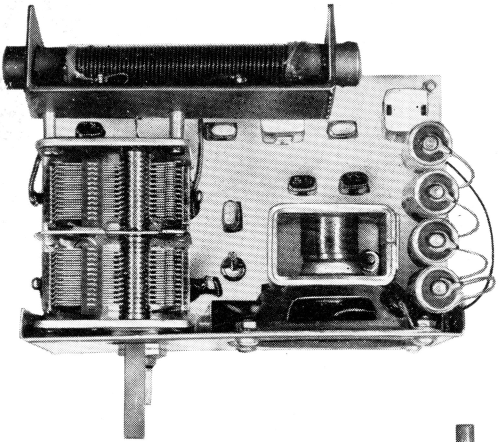
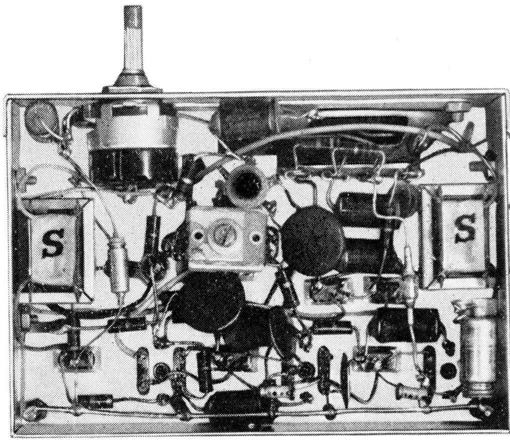
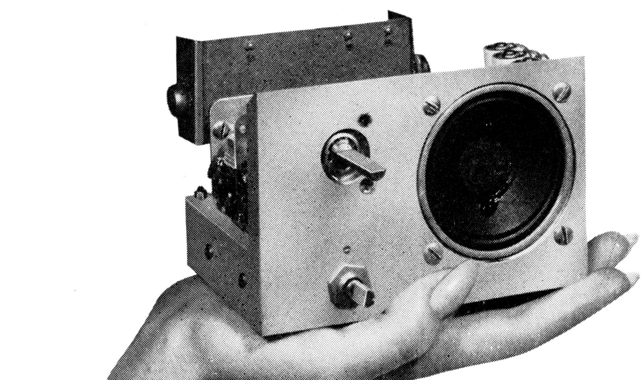






Transistorized Portable Radio.
Complete Instructions and Schematic—See page 12.

CHAPTER 1

Amplifiers

1.1 455-KC I-F Amplifier.

Figure 1-1 is the circuit of a two-stage 455-kc i-f amplifier employing subminiature transformers. The input impedance of this amplifier is approximately 25,000 ohms and output impedance approximately 600 ohms. Power gain is 58 db. Bandwidth is 12 kc at the 3 db points. This amplifier may be incorporated into battery-operated superhet receivers (See Figure 3-5, Chapter 3), frequency meters, wave analyzers, tuned electronic filters, and similar equipment.

The primary windings of the special i-f transformers have impedance-matching taps. The transformers are slug-tuned. The transformer leads are numbered in Figure 1-1 to correspond to the manufacturer's numbering.

If a transistorized converter or 1st detector input stage is employed, the collector of that stage will be connected to terminal 3 of transformer IFT_1. Terminal 4 will be connected to the positive bias terminal.

Oscillation is prevented by neutralization of the amplifier by means of the two 5-uufd fixed capacitors, C_2 and C_6. The circuit will oscillate vigorously if these capacitors are omitted.

Conventional alignment procedure is followed: Connect a 455-kc signal generator (modulated or unmodulated) to the amplifier input terminals. Connect an r-f vacuum-tube voltmeter to the amplifier output terminals. Adjust the screwdriver-tuned slug of each transformer for peak deflection of the v-t voltmeter.

B—Four 1½ v Size-D flashlight cells connected in series for 6 volts
C_1—0.01 ufd 200 v metallized tubular
C_2—5 uufd ceramic
C_3—0.01 ufd 200 v metallized tubular
C_4—0.01 ufd 200 v metallized tubular
C_5—0.01 ufd 200 v metallized tubular
C_6—5 uufd ceramic
C_7—0.01 ufd 200 v metallized tubular
IFT_1, IFT_2, IFT_3—455-kc transistor i-f transformers—Miller 2041
R_1—24K ½ watt
R_2—5.1K ½ watt
R_3—1K ½ watt
R_4—500 ohms ½ watt
R_5—270K ½ watt
R_6—220 ohms ½ watt
S—Spst toggle switch

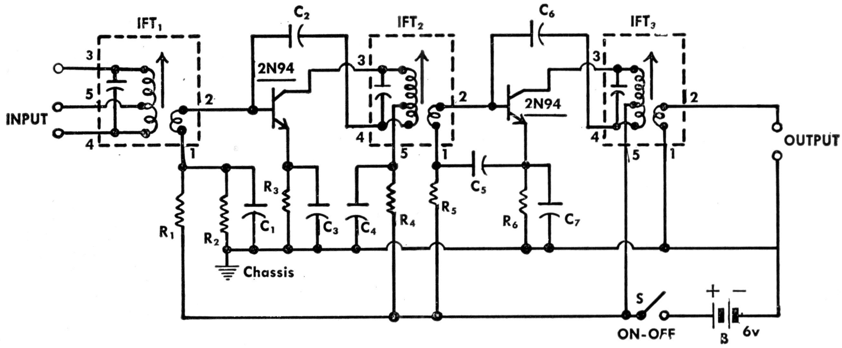


FIGURE 1-1—Transistorized 455-KC I-F Amplifier.

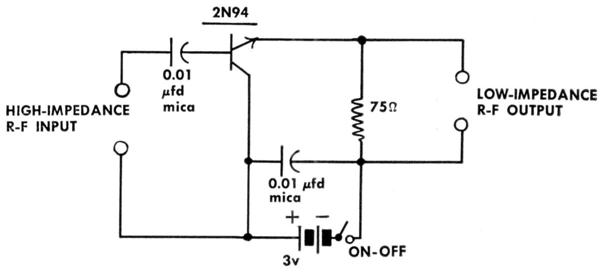
Power is supplied by a 6-volt battery, B. Because of the low current drain of the amplifier, this battery can consist of four Size-D flashlight cells connected in series.

1.2 R-F Impedance Transformer.

Experimental circuitry occasionally calls for a change of impedance from high to low in a signal circuit with minimum loss. The vacuum-tube cathode follower is ideal for this purpose.

Figure 1-2 shows the transistor counterpart of the r-f cathode follower. This is a common-collector circuit which has many of the features of the tube cathode follower. Some of these are higher input than output impedance, excellent frequency response, low distortion of waveform, significant power gain, and negligible phase shift.

The input impedance of this circuit, with the constants shown in Figure 1-2, is approximately 2000 ohms; output impedance 75 ohms. The input impedance may be boosted by raising the output impedance (increasing the size of the emitter output



Input Impedance: approx. 2000Ω
Output Impedance: approx. 75Ω
Power Gain: 2-15 db. @ 1 MC/S

FIGURE 1-2—R-F Impedance Transformer.

resistor). The input impedance roughly will be 25 times the output impedance, in most cases.

Power gain of the impedance-transforming amplifier may vary from 2-15 db, at 1 megacycle.

This amplifier may be made small enough in size to be enclosed in a probe at the end of a coaxial cable. It will have numerous applications in test instruments and signal transfer equipment.

CHAPTER 2

Oscillators

2.1 High-Reliability 100-1000-kc Frequency Standard.

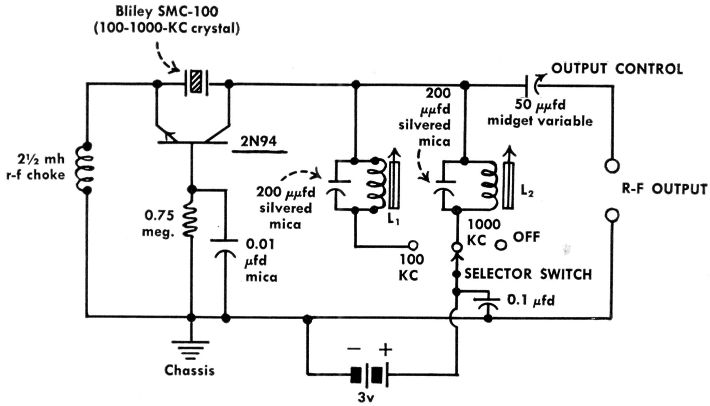
A transistorized crystal-type secondary frequency standard has the advantages of low d-c drain, independence from the power line, freedom from hum and heating, very small size, and completely self-contained construction.

Heretofore, audio-type transistors have been employed to some extent in frequency standards. However, not all transistors have given equally good results at the radio frequencies involved. Individual transistors have failed to work at all.

The r-f type transistor makes possible a completely reliable standard-frequency oscillator in which transistors need no special selection.

Figure 2-1 is the circuit of a 100-1000-kc crystal-type standard-frequency oscillator. A Bliley Type SMC-100, dual mode, crystal is employed. This crystal will oscillate strongly on 100 or 1000 kc, provided the corresponding tuned circuit is operated in the collector output circuit.

Slug-tuned coils, L_1 and L_2, each shunted by a 200-uufd silvered mica capacitor, are employed for tuning. L_1 is the 100 kc inductor; L_2 1000 kc. A single-pole, 3-position, non-shorting, rotary switch is the frequency selector. At its left-hand setting, this switch cuts the 100 kc tank into the collector circuit. At its center setting, the 1000 kc tank is switched-in, and at its right-hand setting (OFF), the battery circuit is interrupted and the signal switched off.



L₁—Slug-tuned 2-18 mh coil (Miller 6314)
L₂—Slug-tuned 54-245 μh coil (Miller 6196)

FIGURE 2-1—High-Reliability 100-1000-KC Frequency Standard.

To tune the oscillator: (1) Set the selector switch to its 100-kc position. (2) Connect an r-f vacuum-tube voltmeter, switched to its 0-1.5 or 0-3-volt range, to the R-F OUTPUT terminals. (3) With an insulated screwdriver, adjust the slug of inductor L_1 for peak deflection of the meter. (4) Set the selector switch to its 1000-kc position. (5) Adjust the slug of inductor L_2 for peak deflection of the meter.

The 50-uufd variable coupling capacitor serves as an r-f output control by varying the impedance in series with the high output terminal.

The low d-c drain of this oscillator allows the use of two 1½-volt penlight cells connected in series as the d-c source. For maximum stability, some engineers prefer to use the large-size flashlight cells and to omit the ON-OFF switch, allowing the instrument to run continuously.

2.2 4.5-MC Crystal TV Sound Marker Oscillator.

Visual TV alignment requires an accurate 4.5-megacycle c-w signal for sound channel marking. Self-excited oscillators are unsuitable for this purpose because of their frequency error.

Some of the older type visual alignment (sweep) signal generators have no provision for crystal-controlling the marker

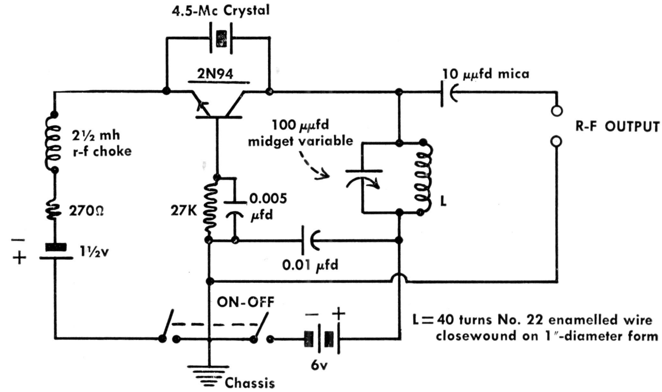


FIGURE 2-2—4.5-MC Crystal TV Sound Marker Oscillator.

circuit for sound-channel pips. An external crystal oscillator must be provided for these instruments.

The 4.5-Mc crystal oscillator shown in Figure 2-2 is convenient for this purpose, since it needs no connection to the power line nor to the sweep generator power supply. It is operated from self-contained flashlight cells.

The tuned circuit consists of a single-layer coil (L) and a 100-uufd midget variable capacitor. To tune the oscillator initially, connect an r-f vacuum-tube voltmeter, switched to its 0-5 or 0-10-volt range, to the R-F OUTPUT terminals and adjust the variable capacitor for peak deflection of the meter. At this point, the collector tank is tuned to the crystal frequency. The tuning then need not be changed subsequently unless the tuning capacitor setting is disturbed.

The small size of the output coupling capacitance (10 uufd) enables the marker oscillator to be connected to a variety of circuits without severe detuning from the crystal frequency.

2.3 High-Frequency Crystal Oscillator.

One of the features of the r-f transistor attractive to the experimenter is its ability to oscillate at high frequencies. This enables the transistorization of a variety of circuits for instrumentation and for control devices.

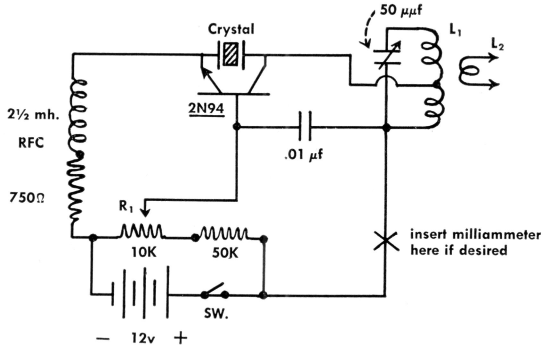


FIGURE 2-3—High-Frequency Crystal Oscillator

Active crystals will oscillate in 2N94 transistor circuits at frequencies up to 5 megacycles with average transistors and up to 7 Mc with individual transistors. Figure 2-3 shows a reliable oscillator circuit.

The circuit is tuned in the normal manner common to tube-type crystal oscillators. That is, the 50-uufd variable capacitor is adjusted for dip of the d-c milliammeter. It should be noted, however, that the dip is not as pronounced in the transistorized oscillator as in its vacuum-tube counterpart.

The inductance of coil L_1 is chosen for resonance with the 50-uufd tuning capacitor (set, say, to 25 uufd) at the crystal frequency. The number of turns, diameter, and length of the coil may be determined by means of the charts or nomograms found in amateur handbooks. Coil L_1 must be center-tapped for connection to the collector. The coupling coil, L_2, consists of 5 turns wound $\frac{1}{8}$ inch from the lower end of L_1. As an example, for 3.5 Mc L_1 would consist of 63 turns of No. 26 enamelled wire closewound on a 1″-diameter form and tapped at the 31st turn.

When the tank is tuned to the crystal frequency, the meter should dip sharply. As the operating frequency is increased, however, oscillation may become more difficult to obtain, especially with some crystals. Here, adjustment of R_1 will promote oscillation as well as rapid starting.

CHAPTER 3

Broadcast Receivers

3.1 Emergency 1-Transistor Pocket Receiver.

Very simple pocket receivers are a perennial favorite of radio hobbyists. Aside from their obvious toy appeal, however, these little sets have possible value for emergency use during disasters when important instructions may be broadcast by local radio stations. Any receiver of this type must be very economical of batteries and should use readily obtainable flashlight batteries, rather than radio batteries.

Fair sensitivity and a reasonable amount of audio output may be obtained from a single audio transistor and a diode detector in a simple receiver circuit. Figure 3-1 shows the hookup.

The tuned circuit consists of a high-Q ferrite antenna coil and 365-uufd variable capacitor. The tuning capacitor here is a new flat unit (1½ inch square and $\frac{3}{16}$ inch thick) which enables the entire receiver, exclusive of headphones, to be built smaller than a cigarette package.

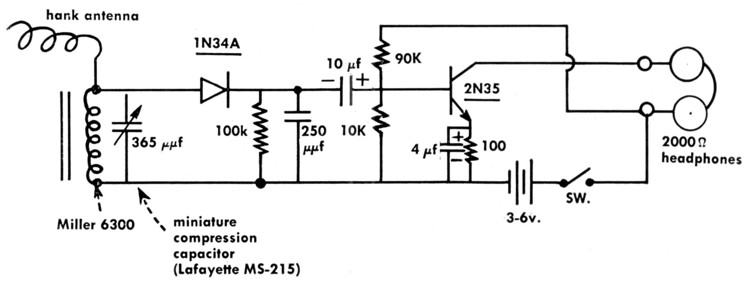


FIGURE 3-1—Emergency 1-Transistor Pocket Receiver.

The antenna is a length of flexible, insulated wire from an ac-dc antenna hank. This wire may be draped from a window or door or thrown across the floor to pick up strong local stations.

Align the set initially in the following manner: (1) Connect an amplitude-modulated signal generator, set to 1600 kc, to the antenna lead. (2) Set the tuning capacitor to its extreme counter-clockwise position. (3) Using an insulated screwdriver, adjust the slug of the antenna coil for maximum signal in the head-phones. (4) If a dial is attached to the tuning capacitor, it may be calibrated by setting the signal generator successively to various broadcast frequencies, tuning them in, and marking the dial with the frequency at each setting.

The 3-volt battery is composed of two 1½-volt penlight cells connected in series.

3.2 Regenerative Broadcast Receiver.

When miniaturization is not required, regeneration may be employed to sensitize a simple transistor receiver. Figure 3-2 shows a circuit of this type employing a 2N94 regenerative detector and 2N35 audio amplifier. With an outside antenna and ground, this arrangement delivers a strong headphone signal on local and nearby stations, but a volume control was not found necessary.

The receiver covers the standard broadcast band with the single 365-uufd tuning capacitor. The variable 75-uufd feedback

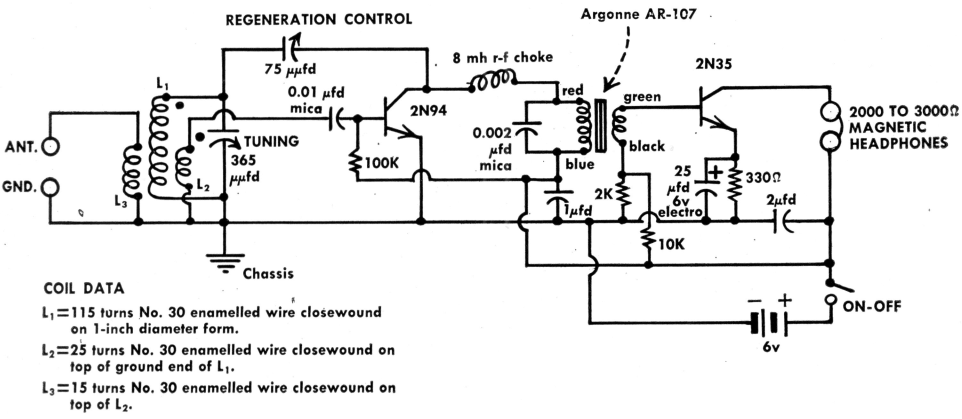


FIGURE 3-2—Regenerative Broadcast Receiver.

capacitor serves as the regeneration control. Current drain is 1½ ma from the 6-volt battery.

Follow the color coding shown in Figure 3-2 for the miniature coupling transformer. If either the primary or secondary leads are reversed, the circuit will oscillate steadily, producing an annoying howl.

If difficulty is experienced in obtaining oscillations try reducing the antenna coupling and/or increasing turns on L_2. Be sure that L_1 and L_2 are phased properly.

3.3 Transistorized Bandpass Tuner.

The bandpass tuner has for several years been the basis of a very popular crystal set operated as an AM tuner ahead of a high-fidelity audio system.

When using a germanium diode in the conventional manner in this type of tuner, the output of the circuit is low except when receiving the strongest local stations. This requires appreciable audio amplification following the tuner.

It is a simple matter to include a transistor audio stage preamplifier, as shown in Figure 3-3, to obtain increased output from the bandpass tuner circuit.

The 2N35 audio amplifier is operated from a 3-volt battery. A base-bias stabilization network is supplied by the 56K and 1.5K resistors in series. Current drain from the battery is approximately 0.6 milliampere.

Tuning is quite sharp and, with a good outside antenna and earth ground, stations within a 30-mile radius are received reliably. The audio amplifier used after this tuner should have a voltage gain of 60 to 100 db for best results.

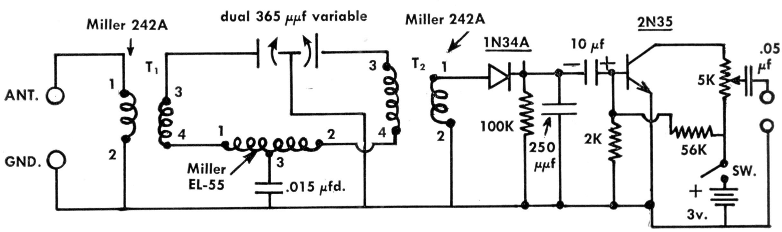


FIGURE 3-3—Transistorized Bandpass Tuner.

This circuit has no avc, and blasting will occur on strong locals unless the volume control is turned down quickly on approaching a strong carrier.

3.4 Four-Transistor, Detector-Amplifier Type Receiver.

This receiver (See Figure 3-4) consists of a 2N94 detector followed by a 2-stage 2N35 audio amplifier. The a-f output stage is a class-B amplifier. Operated from a self-contained ferrite-rod loop antenna and four Size-D flashlight cells, on strong locals this circuit delivers 120 milliwatts of audio to a 3- or 4-inch dynamic speaker. Somewhat lower output is obtained when receiving weaker stations.

The antenna is 10 inches long and should be mounted horizontally in the top of the set. The antenna has a low-impedance tap for connection to the 2N94 base. This arrangement provides good selectivity and efficient signal pickup. The tuning capacitor is connected across the entire antenna coil.

This circuit was not intended for miniaturization, although miniature audio transformers are employed. However, the set may be built in a case somewhat smaller in size than portable battery sets commonly encountered. The 10-inch loop antenna and 4-inch speaker determine the maximum dimensions of the case.

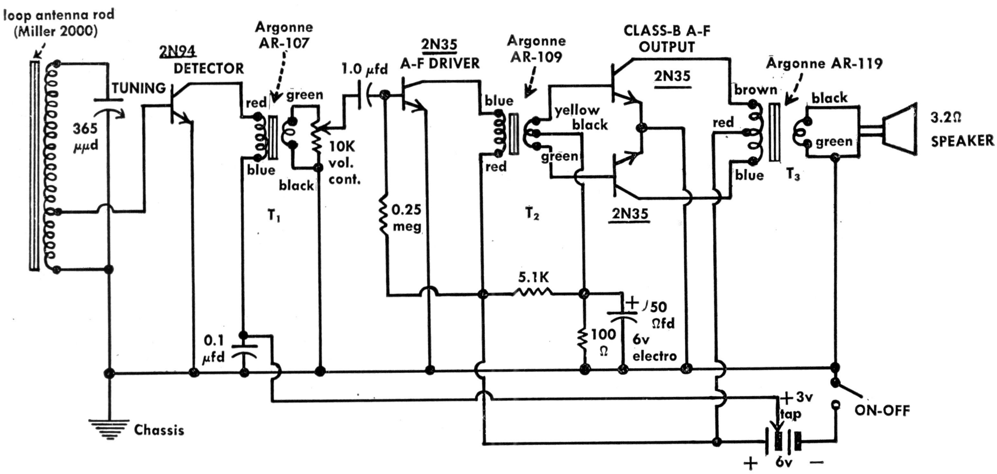


FIGURE 3-4—4-Transistor, Detector-Amplifier Type Receiver.

Power is supplied by four 1½-volt Size-D flashlight cells connected in series, with a tap for +3 volts.

When wiring the circuit, the technician must be careful to observe the correct transformer connections as shown by the color coding in Figure 3-4. Reversal of either of the transformers may cause audio oscillation. If the transformers are mounted close together, they should be oriented so that their cores are at right angles, to minimize magnetic coupling.

3.5 Portable Superhet Receiver.

Best sensitivity and selectivity are obtained with a superheterodyne receiver. Figure 3-5 is the circuit of a transistorized superhet broadcast receiver. This set operates from a self-contained loop antenna (L), has avc, and delivers approximately 110 milliwatts of audio to a 3-inch 3.2-ohm PM dynamic loudspeaker. The d-c supply consists of four 1½-volt Size-D flashlight cells connected in series for 6 volts.

Three 2N94 r-f transistors, three 2N35 a-f transistors, and one 1N34A germanium diode are employed. The 2-stage 455-kc i-f amplifier is similar to the one illustrated in Figure 1-1 and described in Section 1.1, Chapter 1.

Miniature transistor-type i-f transformers (IFT_1, IFT_2, and IFT_3), oscillator coil (T_1), and audio transformers (T_2 and T_3) are employed. The oscillator coil and i-f transformers are slug-tuned. All of the components employed in this receiver are readily-obtainable commercial products.

Tuning throughout the standard broadcast band is accomplished with a conventional, midget 365-uufd dual variable capacitor, C_1-C_6. A compression-type padder, C_5, is provided for oscillator tracking at the low end of the broadcast band.

The antenna, L, is a self-contained, high-Q, ferrite-rod type loop with a low-impedance tap for connection to the base of the 2N94 converter transistor.

Volume control is afforded by the single 10,000-ohm potentiometer, R_{13}. AVC current from the 1N34A second detector is delivered to the front-end stages through resistors R_{11} and R_{12}.

The audio channel consists of a 2N35 single-ended driver and pushpull 2N35 class-B output stage. Correct connections to the audio transformers are indicated by the color coding of the leads

B—Four 1½ v Size-D flashlight cells connected in series for 6 volts

C_1-C_6—Dual 365-uufd midget tuning capacitor—Miller 2112

C_2—0.01 ufd ceramic

C_3—0.01 ufd ceramic

C_4—0.02 ufd

C_5—425-1260 uufd padder—Arco 308-M

C_7—0.01 ufd 200 v metallized tubular

C_8—0.01 ufd 200 v metallized tubular

C_9—5 uufd ceramic

C_{10}—0.01 ufd 200 v metallized tubular

C_{11}—0.01 ufd 200 v metallized tubular

C_{12}—0.01 ufd 200 v metallized tubular

C_{13}—5 uufd ceramic

C_{14}—0.01 ufd 200 v metallized tubular

C_{15}—0.1 ufd 200 v metallized tubular

C_{16}—0.01 ufd 200 v metallized tubular

C_{17}—1 ufd 200 v metallized tubular

C_{18}—0.01 ufd 200 v metallized tubular

C_{19}—0.05 ufd 200 v metallized tubular

C_{20}—0.05 ufd 200 v metallized tubular

IFT_1, IFT_2—455-kc transistor i-f transformers—Miller 2041

IFT_3—455-kc transistor-to-diode i-f transformer—Automatic BS-725

L—Ferrite-rod transistor loop antenna—Miller 2001

R_1—8.2K ½ watt

R_2—1K ½ watt

R_3—1K ½ watt

R_4—24K ½ watt

R_5—5.1K ½ watt

R_6—180K ½ watt

R_7—1K ½ watt

R_8—500 ohms ½ watt

R_9—270K ½ watt

R_{10}—220 ohms ½ watt

R_{11}—3.9K ½ watt

R_{12}—1.1K ½ watt

R_{13}—10K potentiometer

R_{14}—3K ½ watt

R_{15}—100K ½ watt

R_{16}—27 ohms ½ watt

R_{17}—3K ½ watt

R_{18}—100 ohms ½ watt

R_{19}—20 ohms ½ watt

S—Spst switch on volume control potentiometer R_{13}

T_1—Transistor oscillator coil—Miller 2020

T_2—Transistor class-B driver transformer—Argonne AR-108

T_3—Transistor class-B output transformer—Argonne AR-119

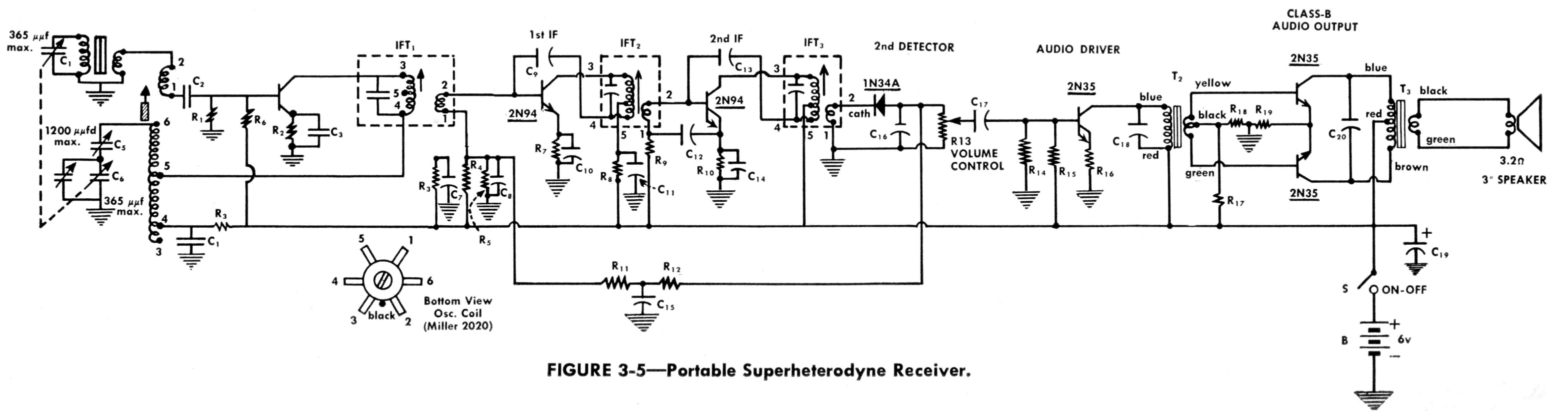


FIGURE 3-5—Portable Superheterodyne Receiver.

shown in Figure 3-5. Do not interchange these connections if audio oscillation is to be avoided.

The technician must be careful also to make connections to the correct terminals of the i-f transformers and oscillator coil. In Figure 3-5, these terminals have been labelled to correspond to the manufacturer's numbering. The No. 3 terminal of the oscillator coil (T_1) is not used in this circuit, therefore is not shown in Figure 3-5. The polarity of the battery and of electrolytic capacitor C_{19} likewise must be observed carefully.

Neutralization of the i-f amplifier is accomplished by means of capacitors C_9 and C_{13}. This is a very necessary feature, since the unneutralized amplifier is strongly regenerative and will oscillate readily.

Initial alignment of the receiver is the same as that performed for a tube-type superhet: The i-f channel is aligned first, with a 455-kc amplitude-modulated signal generator loosely-coupled through a one turn link to the ferrite antenna rod. Next, for front-end alignment, the AM signal generator is set to 1500 kc and the tuning capacitor, C_1-C_6, set to its minimum capacitance (fully open) position. Adjust first the slug of oscillator coil T_1 to its minimum inductance (screw all the way out) position, and then the built-in trimmers on C_6 and C_1 for maximum speaker signal. The tuning capacitor and signal generator then are set to their 535 kc positions, and padder C_5 is adjusted for maximum signal. Return to 1500 kc and readjust the tuning capacitor trimmers, and again return to 535 kc and readjust C_5.

Satisfactory operation is obtained with the oscillator coils specified up to 1550 kc which is more than adequate for most localities. In the event it is desirable to extend the upper frequency range to 1600 kc it will be necessary to lower the inductance of the oscillator tank winding. This can be easily accomplished by removing 10 turns from the tank winding (terminal #6 as indicated on the schematic diagram which shows the bottom view of terminal connection).

CHAPTER 4

Ham Radio

4.1 Novice C-W Transmitter.

An intriguing application of the r-f transistor is in a simple, 80-meter crystal oscillator-type c-w transmitter. The circuit of a typical 1-transistor transmitter is shown in Figure 4-1. While this transmitter can give surprisingly good account of itself under favorable conditions, its very low r-f power output of approximately 15 milliwatts demands that it have an interference-free spot in the band.

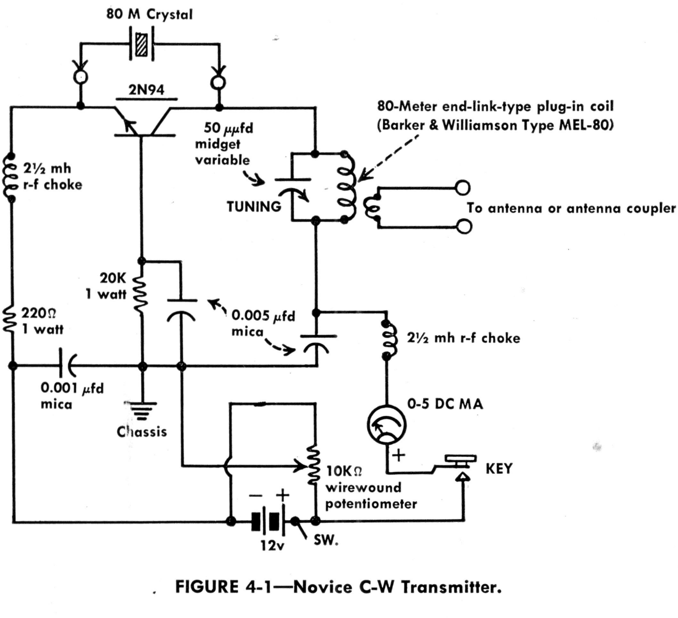


FIGURE 4-1—Novice C-W Transmitter.

An active crystal should be used. When tuning the collector tank to the crystal frequency, the collector current as indicated by the milliammeter will dip. However, this dip is not as deep as in a tube-type oscillator. The 10K-ohm potentiometer should be adjusted, with the key closed, for an off-resonance collector current of not more than 3 ma and so that oscillation starts readily when the key is operated rapidly.

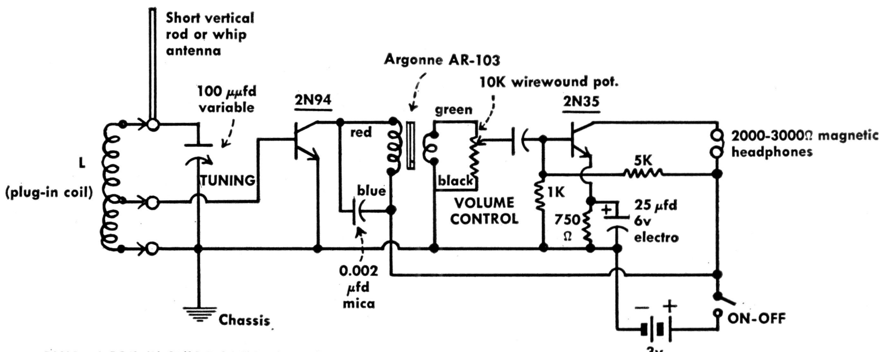
Antenna loading should be adjusted to raise the resonant collector current to 3 milliamperes. Individual transistors may tolerate higher current *under full antenna load.*

Operation of the transmitter beyond the 80-meter band, with the 2N94 transistor, is not recommended.

4.2 Phone Monitor.

Figure 4-2 shows a radiophone monitor suitable for 80- and 160-meter use and offering higher sensitivity than the common diode-type monitor. Close coupling to the transmitter is not required.

A 2N94 tuned detector and 2N36 audio amplifier are employed. With a short vertical whip or rod antenna (2 to 3 feet high), a husky headphone signal is obtained. Operation is reliable



PLUG-IN COIL (L) SPECIFICATIONS

160 Meters. 95 turns No. 30 enamelled wire closewound on 1″-diameter form. Tap 30th turn from ground end.

80 Meters. 46 turns No. 24 enamelled wire closewound on 1″-diameter form. Tap 12th turn from ground end.

FIGURE 4-2—Phone Monitor.

at distances up to several hundred feet from the transmitter. Thus, the monitor is entirely safe to the operator.

D-C power is supplied by a 3-volt battery. Two 1½-volt Size-D flashlight cells connected in series will give long service life, even on a continuous operating basis, since the total current drain is only approximately 2½ milliamperes.

The monitor is built easily into a small metal, radio utility box no larger than a small camera.

4.3 BFO for Communications Receivers.

Because of the filament power required by tubes, it is desirable to eliminate as many tubes as possible when building a new battery-operated communications receiver. One position in which the transistor can function very well in the communications receiver is the beat-frequency (c-w) oscillator. An *external* BFO is required when c-w signals are to be received on a conventional converter-auto radio type of mobile radio system.

In this latter case, the BFO may be operated between 1400 and 1600 kc (i.e., 2nd conversion i.f. freq.). In home-base communications receivers, the BFO frequency is usually 455 kc, although some receivers may use different i.f. frequencies, and therefore require a different BFO frequency.

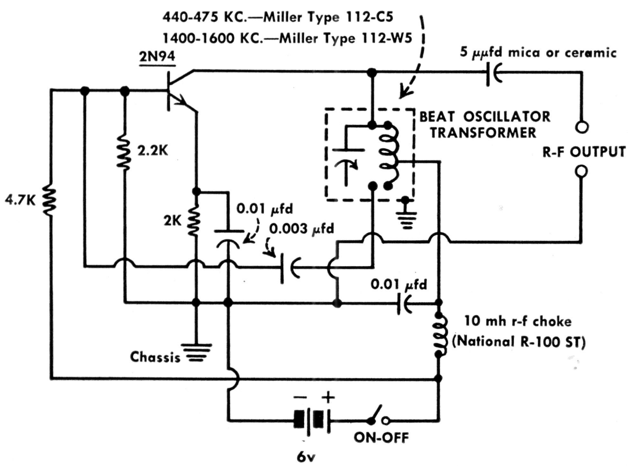


FIGURE 4-3—BFO for Communications Receiver.

A suitable BFO circuit is given in Figure 4-3. This is a Hartley oscillator with resistance-stabilized base bias. A commercial BFO transformer is employed. The tuning capacitor is a part of this shielded transformer, but it may be removed and mounted on the front panel of the instrument if desired.

At 6 volts dc, the total current drain is 2 milliamperes. Oscillation may be obtained at reduced r-f output even at 1½ volts dc and lower current drain.

CHAPTER 5

Test Instruments

5.1 "Grid"-Dip Oscillator.

A battery-operated grid-dip oscillator admittedly is convenient and versatile because of its complete portability and independence from the power line. Such an instrument seldom is attempted, however, because of the poor battery economy of tubes and the inconvenience of the requirement for two batteries—*A* and *B*.

The r-f transistor makes possible a completely self-contained, small-sized dip meter having excellent battery economy and employing small flashlight cells for power. The only important limitation at present is the restricted frequency range of the r-f transistor. However, oscillation has been obtained up to 9 megacycles with individual transistors—and some units might reach even higher frequencies.

Figure 5-1 is the circuit of a dip oscillator with three plug-in coils to cover the frequency range 1 to 9.5 Mc (1-2.2, 2.1-4.5, and 4.4-9.5 Mc). This is a bias-stabilized oscillator of the Hartley type operated at 4½ volts dc.

The r-f indicator is a 1N34A shunt diode detector and 0-100 d-c microammeter, capacitance-coupled across the tuned circuit through capacitor C_2. The METER CONTROL rheostat, R_5, permits setting the meter to full scale at any part of either coil range. Adjustment of the OSCILLATION CONTROL rheostat, R_4, enables oscillation to be sustained throughout each frequency band.

The accompanying COIL TABLE gives winding instructions for the three coils. The latter are wound on 1″-diameter plug-in forms. The tuning capacitor, C_4, is a 140-uufd straight-line-frequency, midget variable.

C_1—0.001 ufd mica
C_2—15 uufd mica
C_3—0.001 ufd mica
C_4—140 uufd midget variable
C_5—0.01 ufd mica
L—See COIL TABLE
R_1—1.8K ½ watt carbon
R_2—2.2K ½ watt carbon
R_3—1.8K ½ watt carbon
R_4—2K wirewound potentiometer
R_5—75K potentiometer
RFC—2½ millihenry r-f choke
S—Spst toggle switch

DIP OSCILLATOR COIL TABLE

1 to 2.2 Mc.	102 turns No. 30 enamelled wire closewound on 1″-diameter plug-in form. Tap 51st turn from lower end.
2.1 to 4.5 Mc.	46 turns No. 24 enamelled wire closewound on 1″-diameter plug-in form. Tap 23rd turn from lower end.
4.4 to 9.5 Mc.	23 turns No. 24 enamelled wire on 1″-diameter plug-in form. Space to winding length of 1 inch. Tap 11th turn from lower end.

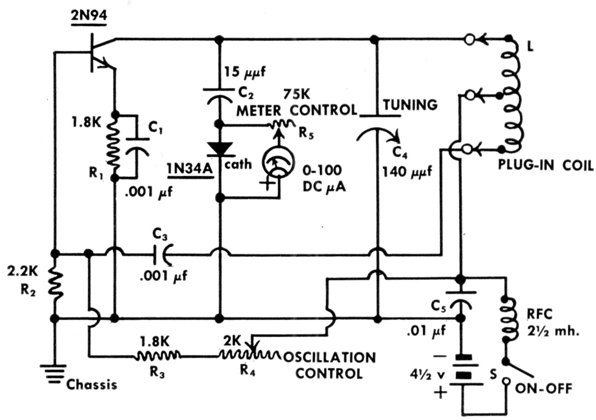


FIGURE 5-1—"Grid"-Dip Oscillator.

The 4½-volt battery can consist of three series-connected flashlight cells. When the instrument is to be used only occasionally, these may be penlight cells.

5.2 Multi-Crystal R-F Alignment Oscillator.

A crystal-type signal generator is convenient as a spot-frequency oscillator particularly for use in receiver alignment and instrument calibration. Within practical limits, any number of crystals can be used. Since no tuning is required, test frequencies may be switched rapidly.

Figure 5-2 is the circuit of a crystal-type modulated oscillator. Four crystals are shown. The FREQUENCY SELECTOR switch, S_1-S_2, cuts a particular crystal into the circuit at the same time

the corresponding pre-tuned collector tank circuit is selected. For example, the 455-kc crystal is selected simultaneously with the 455-kc pre-tuned tank, L_1C_3. Each tank coil (L_1 to L_4) is slug-tuned.

The base rheostat, R_2, serves as an r-f output control. Switch S_3 is closed to start the 2N94 r-f oscillator; switch S_4 to start the 2N35 1000-cycle modulator. Thus, either modulated or un-modulated r-f output is available. Rheostat R_3 is provided with a slotted shaft for screwdriver adjustment and controls the wave-form of the a-f modulating voltage. High-impedance r-f output is provided through coupling capacitor C_4.

C_1, C_2—0.01 ufd mica
C_3—250 uufd silvered mica
C_4—10 uufd silvered mica
C_5—100 uufd silvered mica
C_6—75 uufd silvered mica
C_7—100 uufd silvered mica
C_8—0.004 ufd metallized tubular
C_9—0.25 ufd metallized tubular
L_1, L_2—0.185-1 mh slug-tuned coil—Miller 6195
L_3—0.054-0.245 mh slug-tuned coil—Miller 6196
L_4—9-16 microhenry slug-tuned coil—Miller 4506
R_1—500K ½ watt carbon
R_2—500K potentiometer
R_3—2K wirewound potentiometer
R_4—2.7K ½ watt carbon
R_5—1.5K ½ watt carbon
R_6—27K ½ watt
RFC_1, RFC_2—2½ millihenry r-f chokes
S_1-S_2—2-pole, 2-11-position, non-shorting, rotary selector switch
S_3, S_4—Spst toggle switches
T—U. T. C. Type 0-7 Ouncer transformer

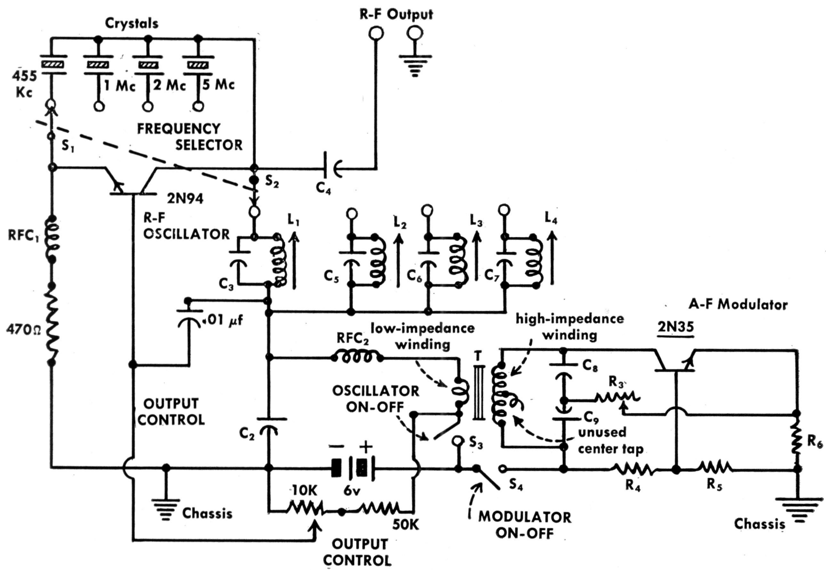


FIGURE 5-2—Multi-Crystal R-F Alignment Oscillator.

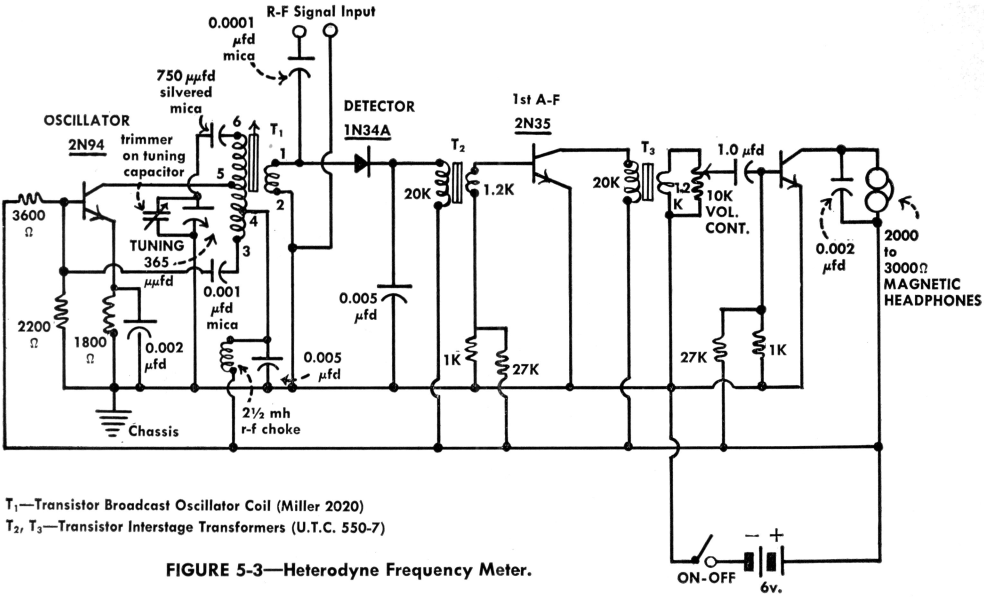
Each of the tuned circuits (L_1C_3, L_2C_5, L_3C_6, and L_4C_7) is pre-tuned to its crystal frequency in the following manner: (1) Connect an r-f vacuum-tube voltmeter to the R-F OUTPUT terminals. (2) Switch-on the oscillator and set rheostat R_2 for maximum meter deflection. (3) Set switch S_1-S_2 for the desired crystal frequency and tune the corresponding tank to resonance by adjusting the coil slug for peak deflection of the meter. (4) Rheostat R_3 may be set for best audio waveform either by means of an oscilloscope connected across the high-impedance winding of transformer T, or by listening to the oscillator signal with a receiver connected to the R-F OUTPUT terminals and setting R_3 for the cleanest tone.

5.3 Heterodyne Frequency Meter.

Figure 5-3 is the circuit of a conventional heterodyne frequency meter transistorized for small size, portability, and economical battery operation. The heterodyne frequency meter is convenient for the measurement of radio frequencies over a wide range.

This instrument consists of a 2N94 r-f oscillator continuously variable and direct-dial-calibrated from 500 to 1000 kc, 1N34A detector-mixer, and 2-stage 2N35 audio amplifier. Headphones are used as the beat note detector. Operation is from a self-contained 6-volt battery which can be four Size-D flashlight cells connected in series.

The operating principle of the heterodyne frequency meter is simple. The unknown signal is applied to the R-F SIGNAL INPUT terminals either by direct connection to the signal source or by antenna pickup. The oscillator is tuned to zero beat with this signal, as indicated by headphone tone. At this point, the signal frequency is determined from the oscillator frequency. That is, from the calibrated oscillator dial setting. The unknown signal frequency may be either identical with the oscillator frequency (f) or it may be a harmonic or subharmonic of f. Thus, signals may be detected and measured all the way from about 1/10 f to 20 or 30 f. In the first instance, harmonics of the test signal beat with the oscillator; in the other case, harmonics of the oscillator beat with the test frequency. In this way, an oscillator range of 500 to 1000 kc is satisfactory for checking frequencies from 50 kc to 20 or 30 megacycles. The limiting factor is audibility —after a certain separation between signal and oscillator frequen-



T_1—Transistor Broadcast Oscillator Coil (Miller 2020)
T_2, T_3—Transistor Interstage Transformers (U.T.C. 550-7)

FIGURE 5-3—Heterodyne Frequency Meter.

cies, the beat note becomes too weak for accurate setting to zero.

The oscillator dial may be calibrated initially by the zero beat method by means of accurately-known signals fed into the R-F SIGNAL INPUT terminals. The trimmer on the tuning capacitor is used for alignment with the upper-limit frequency 1000 kc.

The oscillator coil, T_1, is a commercial transistor-type component. The terminals of this unit are labelled in Figure 5-3 to correspond to the manufacturer's numbering.

5.4 Modulated R-F Test Oscillator.

A tunable signal generator for broadcast and intermediate frequencies is shown in Figure 5-4. This instrument covers the range 420 to 1700 kc and provides both unmodulated and 1000-cycle modulated r-f output.

Operated from a 7½-volt battery, the circuit employs a 2N94 r-f oscillator, 2N35 a-f oscillator, and 1N34A amplitude modulator.

The single tuning range, 420-1700 kc, is covered by means of the 730-uufd variable capacitor obtained by parallel-connecting the two sections of a dual 365-uufd unit.

C_1—0.002 ufd mica
C_2—0.1 ufd metallized tubular
C_3-C_4—Dual 365 uufd variable
C_5—0.1 ufd metallized tubular
C_6—250 uufd mica
C_7—0.004 ufd
C_8—0.25 ufd metallized tubular
L_1—110 turns No. 32 enamelled wire closewound on 1″-diameter form. Tap 44th turn from lower end
L_2—7 turns No. 32 enamelled wire closewound around lower end of L_1
R_1—2.2K ½ watt carbon
R_2—2K ½ watt carbon
R_3—300 ohms ½ watt carbon
R_4—1200 ohms ½ watt carbon
R_5—12K ½ watt carbon
R_6—1000-ohm wirewound potentiometer
R_7—2.7K ½ watt carbon
R_8—2K wirewound potentiometer
R_9—1.5K ½ watt carbon
R_{10}—27K ½ watt carbon
RFC—10 millihenry r-f choke
S_1-S_2—Dpst toggle switch
S_3—Spst toggle switch
T—U. T. C. Type 0-7 Ouncer transformer

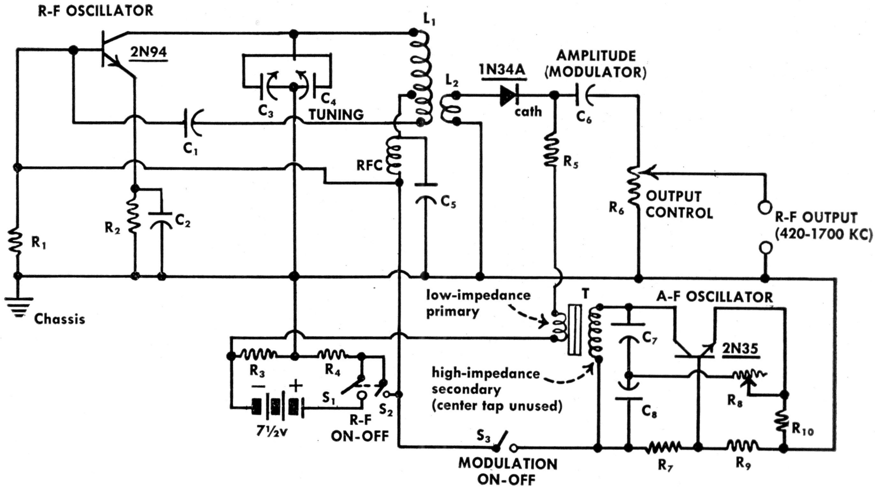


FIGURE 5-4—Modulated R-F Test Oscillator.

The 1N34A modulating diode receives its d-c bias from the common battery through the R_3-R_4 resistor network. Potentiometer R_6 is the R-F OUTPUT control.

R-F output is available as soon as switch S_1-S_2 is closed. 1000-cycle-modulated r-f is obtained when, in addition, switch S_3 is closed. Rheostat R_8 is adjusted for clean tone modulation, as indicated by a receiver connected to the R-F OUTPUT terminals of the instrument and tuned to the output frequency.

The instrument may be calibrated against another oscillator or frequency standard, using the zero beat method. The trimmers of the tuning capacitor, C_3-C_4, then may be used for correction during calibration re-checks.

5.5 R-F Capacitance Meter.

Figure 5-5 shows a tunable instrument for checking capacitance by the substitution method at 1 megacycle. Its range is 0 to 325 uufd.

The circuit comprises a 2N94 1000-cycle crystal oscillator, external capacitance-checking tuned circuit ($L_3C_1C_2$) link-coupled to the oscillator tank; and r-f voltmeter consisting of a 1N34A germanium diode, 0-50 d-c microammeter, and METER SENSITIVITY rheostat.

The crystal oscillator is pre-tuned by adjusting the slug of inductor L_1 for peak deflection of an r-f vacuum-tube voltmeter connected temporarily between the 2N94 collector and ground.

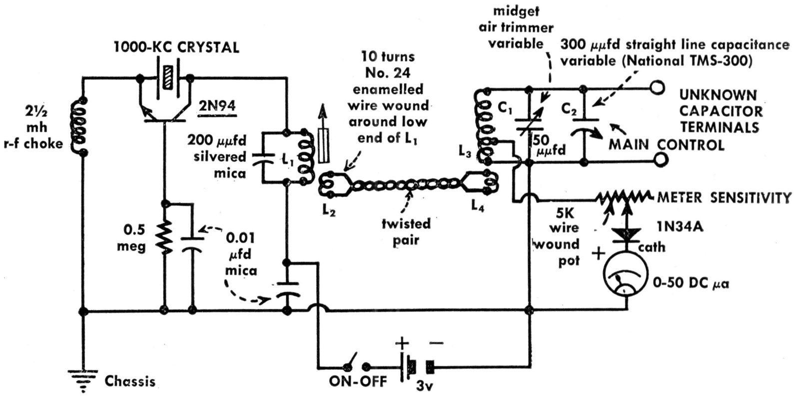
The external tuned circuit is resonated to the oscillator frequency by adjusting capacitor C_2 for peak deflection of the microammeter. Resonance should occur with C_2 set to maximum capacitance and C_1 to mid-range. If the pointer is driven off the microammeter scale, adjust the METER SENSITIVITY control to a higher-resistance point.

To calibrate the dial of capacitor C_2: (1) Switch-on the oscillator and disconnect the top of coil L_3 temporarily from C_1 and C_2. (2) Set C_1 to mid-range and C_2 to maximum capacitance, the positions previously determined for resonance with the oscillator. (3) Connect an accurate capacitance bridge to the UNKNOWN CAPACITOR terminals, check the total capacitance $C_1 + C_2$ and mark this value on the C_2 dial at this setting. This capacitance value will be referred to hereafter as C_Y. (4) Set the bridge to a capacitance value 10 uufd lower than C_Y, and adjust C_2 for bridge null. Mark this capacitance value on the C_2 dial. (5) Repeat in 10-uufd steps until the minimum-capacitance setting of C_2 is reached. (6) Remove the bridge and reconnect coil L_3.

To use the instrument: (1) Switch-on the d-c power. (2) With the UNKNOWN CAPACITOR terminals open, resonate the measuring circuit by setting C_2 to maximum capacitance (C_Y) and tuning C_1 for peak deflection of the microammeter. Increase the resistance setting of the METER SENSITIVITY control if the pointer is driven off scale. (3) Connect the unknown capacitance to the UNKNOWN CAPACITOR terminals *by the shortest possible leads.* (4) This connection detunes the circuit and the meter reading will drop. Now, set C_2 to a lower capacitance to restore resonance, as indicated by peak upswing of the meter. Do

not disturb the setting of C_1. (5) Read the capacitance (C_Z) at this second setting of the calibrated dial of C_2. (6) The unknown capacitance C_X then equals the difference between the two dial settings. That is, $C_X = C_Y - C_Z$. Very small capacitances may be measured in this manner.

For direct readings requiring no calculations, the C_2 dial may be marked zero at the maximum-capacitance of the main capacitor and then graduated 10, 20, etc. at the succeeding 10-uufd steps up to 325 uufd at the minimum-capacitance setting of C_2. At the second adjustment (C_Z) of the C_2 dial, the unknown capacitance then may be read directly in micromicrofarads from the dial.



L_1—Slug-tuned 54-245 μh coil (Miller 6196)

L_3—67 turns No. 28 enamelled wire closewound on 1″-diameter form. Tap 26th turn from ground end.

L_4—6 turns No. 28 enamelled wire closewound around ground end of L_3.

FIGURE 5-5—R-F Capacitance Meter.

CHAPTER 6

Miscellaneous Devices

6.1 Wireless Phono Oscillator.

A battery-operated phonograph oscillator for wireless transmission into a broadcast receiver is attractive because it requires no connection to the power line and is hum-free. Transistors make possible economical battery operation of this device.

Figure 6-1 is the circuit of a simple phono oscillator unit employing a 2N94 fixed-tuned r-f oscillator and 2N35 modulator. A short length of flexible, insulated wire (ac-dc antenna hank) serves as the transmitting antenna.

The oscillator frequency is adjusted by means of a 0.2-3-millihenry slug-tuned inductor. The frequency may be shifted throughout the broadcast band to any clear spot on the receiver dial. The oscillator is a Colpitts-type circuit.

Operated from a self-contained 3-volt battery, the circuit draws 1.6 ma.

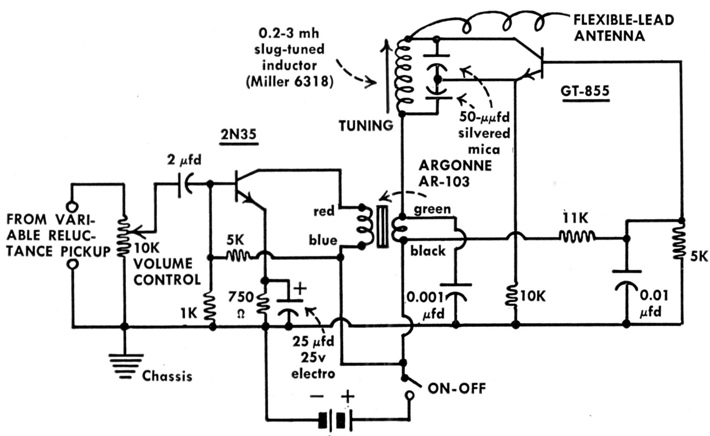


FIGURE 6-1—Wireless Phono Oscillator.

6.2 Wireless Mike.

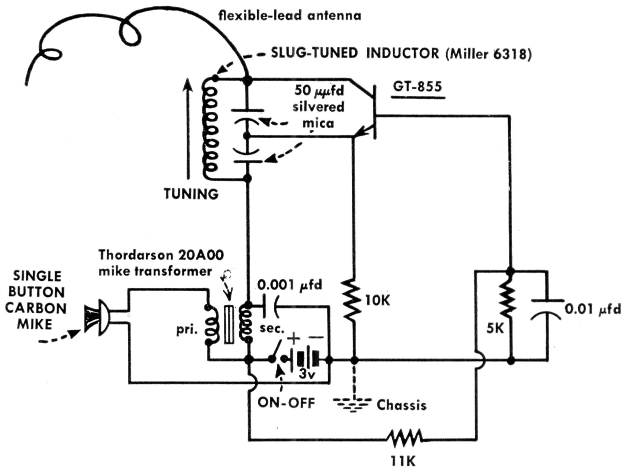


FIGURE 6-2—Wireless Mike.

The wireless microphone circuit of Figure 6-2 operates somewhat the same as the phono oscillator described in the preceding Section 6.1, except that the mike permits voice announcements to be made through the radio receiver tuned to the circuit frequency. Like the phono oscillator, the wireless mike may be tuned through the standard broadcast band.

A 2N94 fixed-tuned r-f oscillator is employed. By using a carbon microphone, sufficient audio power is obtained on speech to modulate the oscillator directly without an audio amplifier stage. Some carbon mikes may require less bias than the 3 volts shown. If "packing" of the carbon granules occurs the bias should be reduced.

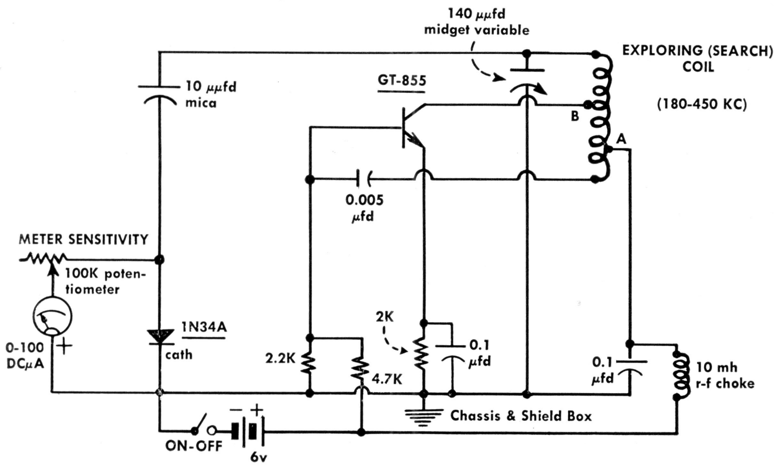
The oscillator is tuned by means of the screwdriver-adjusted slug in the coil. The antenna, like that of the phono oscillator, is a short length of flexible, insulated wire (ac-dc antenna hank). A short vertical antenna, such as a 1- to 2-foot length of stiff wire, also may be used as a transmitting antenna.

6.3 Simplified Metal Locator.

Figure 6.3 is the circuit of a simple, low-frequency r-f oscillator for locating hidden metallic objects at a distance of 1 to 2 feet. The distance over which the device is effective depends upon the size of the object and the kind of material in which it is buried. This device is handy for locating pipes, wiring, nails, etc. in walls, ceilings, and under floors.

The modified Hartley oscillator is tunable from 180 to 450 kc by means of the 140-uufd variable capacitor. The higher frequencies in this range seem to be more effective for locating small-sized objects. The indicator is an r-f voltmeter comprised of the 0-100 d-c microammeter, 100K METER SENSITIVITY potentiometer, 1N34A germanium diode, and 10 uufd coupling capacitor. With the battery switched-on, the potentiometer is set for full-scale deflection of the meter. If a metal object then comes within the field of the search coil, it will detune the oscillator slightly and cause the meter reading to increase or decrease sharply. When the metal passes out of the field, the deflection returns to its original level.

The search coil should be mounted so that it may be swung around to present either its side or bottom to the area suspected



EXPLORING COIL SPECIFICATIONS:

230 turns No. 32 enamelled wire closewound on 4″-diameter, 2½″ high form. Tap A 40 turns from low end. Tap B 100 turns from low end.

FIGURE 6-3—Simplified Metal Locator.

to contain hidden metal. The tuning capacitor may be set for any frequency in the tuning range. However, as stated earlier, the higher frequencies should be used when small-sized objects are suspected.

This metal locator is *not* satisfactory for underground treasure hunting, although it is capable of picking out a sewer top or car track that has been covered with a relatively thin topping of asphalt. The reason is that the r-f output of the 2N94 transistor is too low for deep penetration into the soil.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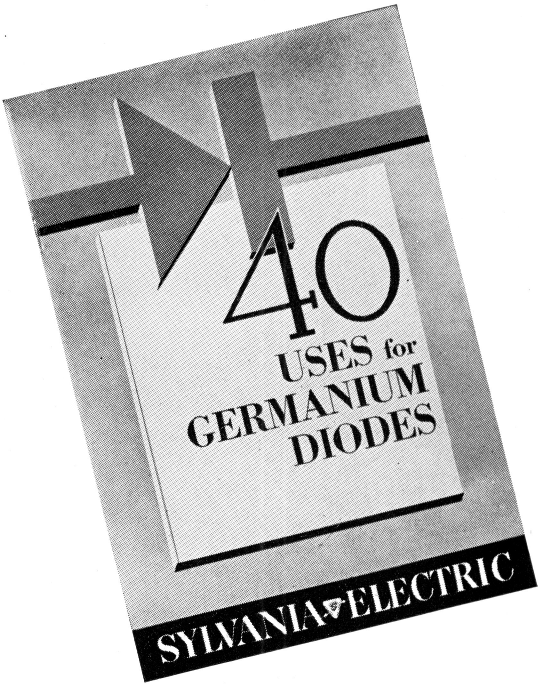

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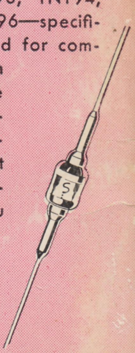

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